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INSTRUMENTATION FOR HUMAN FACTORS MEASUREMENT IN THE TROPICS IV: A SHORT LAND NAVIGATION TEST

By

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MARCH 1977

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APO MIAMI 34004

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A Short Land Navigation Test Course was established in the Republic of Panama jungle to serve as a performance-decrement measure for soldiers who carry materiel items on portability tests at the US Army Tropic Test Center (USATTC). The land navigation test contained six segments within an 80-foot-radius circle in the tropic forest. Four different six-segment problems were compared for degree of difficulty using four types of scores. There were no differences in difficulty among the four problems. The land navigation test

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produced significantly reliable scores and sufficiently small standard errors of measurement to be useful as a performance-decrement measure in conjunction with portability tests in tropic forests.

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A Short Land Navigation Test Course was established in the Republic of Panama jungle to serve as a performance-decrement measure for soldiers who carry materiel items on portability tests at the US Army Tropic Test Center. The land navigation test contains six segments within an 80-foot-radius circle in the tropic forest. The reliabilities of four types of scores were tested: Segments correct, azimuth error, error in estimating distance traveled, and travel rate. Distance estimate error and travel rate were more reliable (r_{xx} = 0.83 and 0.69) than the number of correct segments and azimuth error (r_{xx} = 0.34 and 0.33). Four different six-segment problems were compared for degree of difficulty across the four types of scores. There were no differences in difficulty among the four different problems. The land navigation test produced significantly reliable scores and sufficiently small standard errors of measurement to be useful as a performance-decrement measure in conjunction with portability tests in tropic forests.

I. BACKGROUND

A. INTRODUCTION

The US Army Tropic Test Center (USATTC) has developed a human factors jungle test area in its Gamboa forest test site in the Canal Zone. The need for objective performance data based on specific repeatable tasks and conditions has been a main concern among human factors personnel for many years. Included in the test area are portability courses,[1] laser rifle-fire accuracy tests,[2] visual target detection tests,[3-9] auditory localization test sites,[10] and physiological safety monitoring instrumentation.[11] Each of the tests is tied to a permanent physical facility and has established data collection procedures (figure 1).[12-13] This report describes a land navigation test contained within the jungle.

B. OBJECTIVES

The objective of this USATTC research was to develop a land navigation ability test that would provide reliable data before and after a soldier traverses a 4-kilometer man-pack portability course (MPPC) while carrying a materiel item undergoing tropic testing. The land navigation test, then, would serve as a performance-decrement measure.

The goal in future research is to develop normative land navigation decrement data for various loads that are carried over the portability course. Beyond the normative data collection, the land navigation course will serve as a standard performance course to be used in conjunction with the portability course and the laser rifle accuracy test during development tests of Army materiel items that must be carried or worn in the jungle. The land navigation test, as well as the other test systems, is designed to provide objective methods for making three basic types of comparisons commonly required in military testing: new system versus standard system, new system versus no system, and new system versus criterion data.

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[1] Human Performance in the Tropics I: Man-Packing a Typical Load Over a Standard Jungle Course in the Wet and Dry Seasons, Sep 74.
[2] Instrumentation for Human Factors Measurement in the Tropics III: A Rifle-Fire Simulator Test in the Jungle, Mar 76.
[3-9] Jungle Vision I through VIII: Apr 64 through Oct 71.
[10] Jungle Acoustics III: Effects of an Acoustic Filter on the Detection of Voices through the Jungle Canopy, Jul 72.
[11] Instrumentation for Human Factors Measurement in the Tropics II: A Biotelemetry Safety Monitoring System for Jungle Patrols, Oct 75.
[12] TECOM Draft TOP 1-3-550, Man-Pack Portability Testing in the Tropics, Jan 73.
[13] TECOM Draft TOP 1-1-054, Ground-to-Ground Target Detection in Tropic Forests, Mar 74.

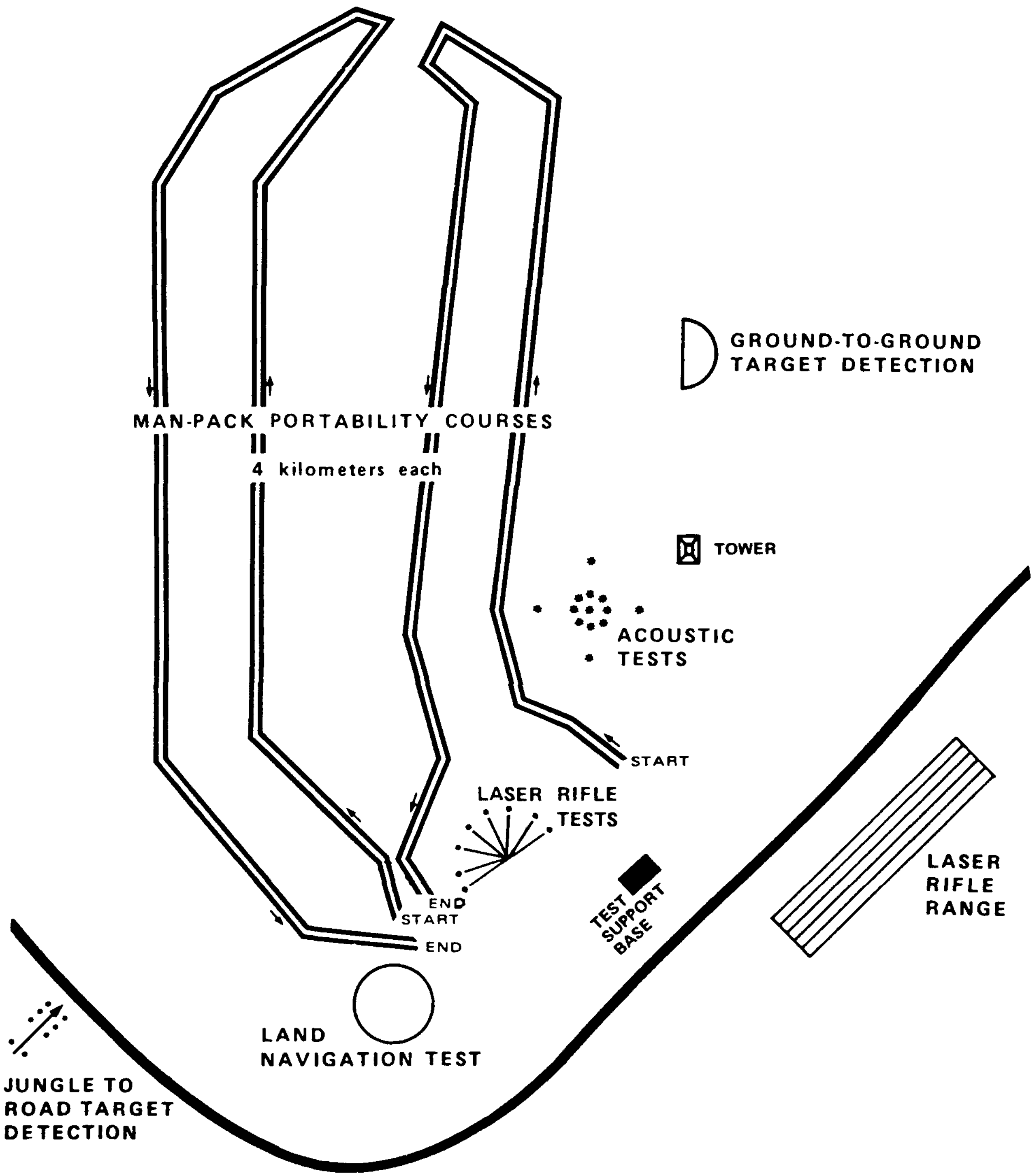


Figure 1. Human Factors Jungle Test Area.

II. METHOD

A. LAND NAVIGATION TEST METHODS

Instruction and Practice. Instructions on the use of the compass, and practice in distance estimation and land navigation, were given to each subject at a special practice test site shown in the layout at figure 2. The instructions were played from recorded tapes in order that all subjects would receive identical instructions (see Appendix A, tape I, for complete instructions). The subjects reviewed the parts of the compass, functions of the compass, and techniques for using the compass. Instructions for this phase are transcribed in Appendix A, tape II. Each subject practiced pacing by walking in the jungle between two stakes, 10 meters apart. The subject counted his steps as he walked so that later he could use the number of steps in 10 meters as a gauge to estimate distance. Specific instruction was given on methods for converting steps to meters. After general instructions and pacing practice, soldiers were assigned a land navigation practice problem. The problem consisted of three segments. (1) The soldier shot a given azimuth from an origin point. He walked along the azimuth line, counting his steps as he walked, until he found a numbered 2- by 4-inch stake sticking 3 feet out of the ground (stake 3 or 4). When he arrived at the stake, he entered on a score card the stake number and the number of meters he had walked. (2) From the first stake, he shot another given azimuth. He walked until he found another 2- by 4-inch stake in the ground with another number on it (stake 3 or 4). He again estimated the distance and entered the data on his score card. After he completed the second segment, he returned to the origin point where his work was critiqued. (3) He was then given a third segment to walk for final practice. The third segment ended at one of five small stakes (1 by 2 by 10 inches high) at 34 meters distance from the origin (stakes 5 through 9).

Test Site Layout. The land navigation course is located inside the forest adjacent to the starting and ending point of the MPPC (figure 1). It is laid out as a circle with a radius of 80 feet. Figure 3 gives a 360-degree panoramic view of the test area. Figure 4 shows a soldier on the course during the land navigation test. The circumference of the circular course is divided into twenty-four 15-degree arcs. The 24 points are marked with 1- by 2- by 10-inch stakes (shown in insert to figure 3) numbered from 1 to 24. The magnetic azimuth from the center of the circle to stake 1 is 265 degrees. The selection of this azimuth as stake 1 was based on a visual inspection of the terrain and vegetation. In the visual inspection, a line of symmetry was chosen that would place generally equal topography and vegetation in each semicircle. The first stake at the end of the line of symmetry was numbered 1. The remaining numbers ascended clockwise through 24, which closed the circle.

Four problems were selected. They were coded red, black, green, and blue. The red and black problems were mirror images of each other, as were the green and blue. Sketches of the four problems are shown in figures 5 and 6. Each problem had six segments, with the first starting from the center of the circle. Total distance for each of the four problems was the same--213.21 meters.

Procedure. The subject was instructed to shoot six segments in succession in accordance with the azimuths marked on his problem card (figures 5 and 6), and to start at the center stake. Segments 2 through 6 began at the stakes recorded for the previous segments (see Appendix A for complete instructions). The stake numbers and the distance estimates for successive stakes were written on the card as the six segments were completed. The problems were timed by a scorer, starting when the subject raised his compass for the first segment and ending when he entered the data for the sixth segment. White tape was strung about 10 meters beyond the perimeter of the circle to prevent the subjects from straying outside the test area.

Scoring Procedure. The course was designed to eliminate test subject/test monitor interaction. Although a subject would miss the correct stake on one segment, he could still obtain correct scores for subsequent segments. The steps outlined below show details of the scoring procedure for a particular problem. The sample score card and problem diagram in figure 7 show that column 1 of the card is the sequence of the six segments. Column 2 provides the azimuth for the subject to follow on each segment. Column 3, above the diagonal line, shows where he should have arrived. In column 4, above the diagonal, is the distance estimated by the subject in meters. Below, is the straight-line distance actually traveled between stakes. The numbers above the diagonal were entered by the participant, and those below by the scorers at a later time. In the problem diagram in figure 7, the solid lines indicate the path the subject would have followed if all segments were completed correctly. The dashed lines follow the route he actually walked. The problem was scored as follows (see summary tabulation below):

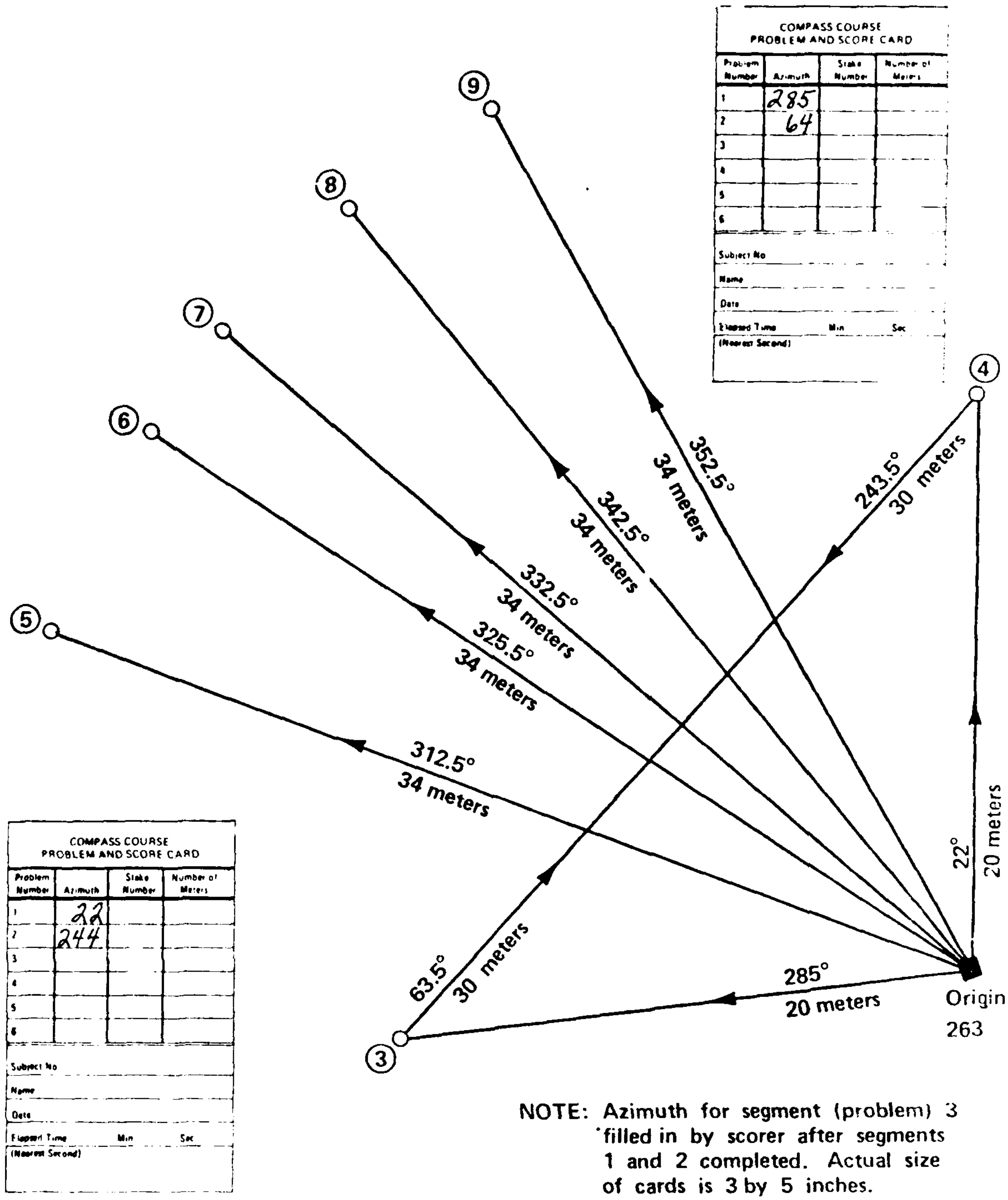
Step 1 Subject's first azimuth was 145 degrees; he should have arrived at stake 17.

Step 2 Subject erred and arrived at stake 18. Segment was incorrect, one stake to the right (1R).

Step 3 Subject estimated a distance of 28 meters between the center stake and stake 18. By reference to the circular conversion chart shown in figure 8, the true distance was 24.38 meters; subject over-estimated 3.62 meters (+3.62).

Step 4 Subject's second azimuth was 273 degrees. He should have arrived at stake 21. Starting at 18, subject should have moved parallel to solid line on figure 7 running from 17 to 11, thus making stake 21 correct; however, he erred and arrived at stake 22. Segment was incorrect, one stake to the right (1R).

Step 5 Subject estimated a distance of 36 meters. An in-house constructed conversion chart, figure 8, shows the true distance from stake 18 to stake 22 to be 24.38 meters, an overestimate of 11.62 meters (+11.62).



NOTE: Azimuth for segment (problem) 3 filled in by scorer after segments 1 and 2 completed. Actual size of cards is 3 by 5 inches.

Figure 2. Land Navigation Practice Test Layout and Score Cards.

Figure 3. 360 Degree Panorama of Marker.

Figure 4. Soldier on Test Course.

COMPASS COURSE PROBLEM AND SCORE CARD

Problem Number	Azimuth	Stake Number	Number of Meters
1	145		
2	273		
3	63		
4	265		
5	55		
6	198		

Subject No.

Name

Date

Elapsed Time Min Sec
(Nearest Second)

COMPASS COURSE PROBLEM AND SCORE CARD

Problem Number	Azimuth	Stake Number	Number of Meters
1	10		
2	243		
3	92		
4	250		
5	100		
6	319		

Subject No.

Name

Date

Elapsed Time Min Sec
(Nearest Second)

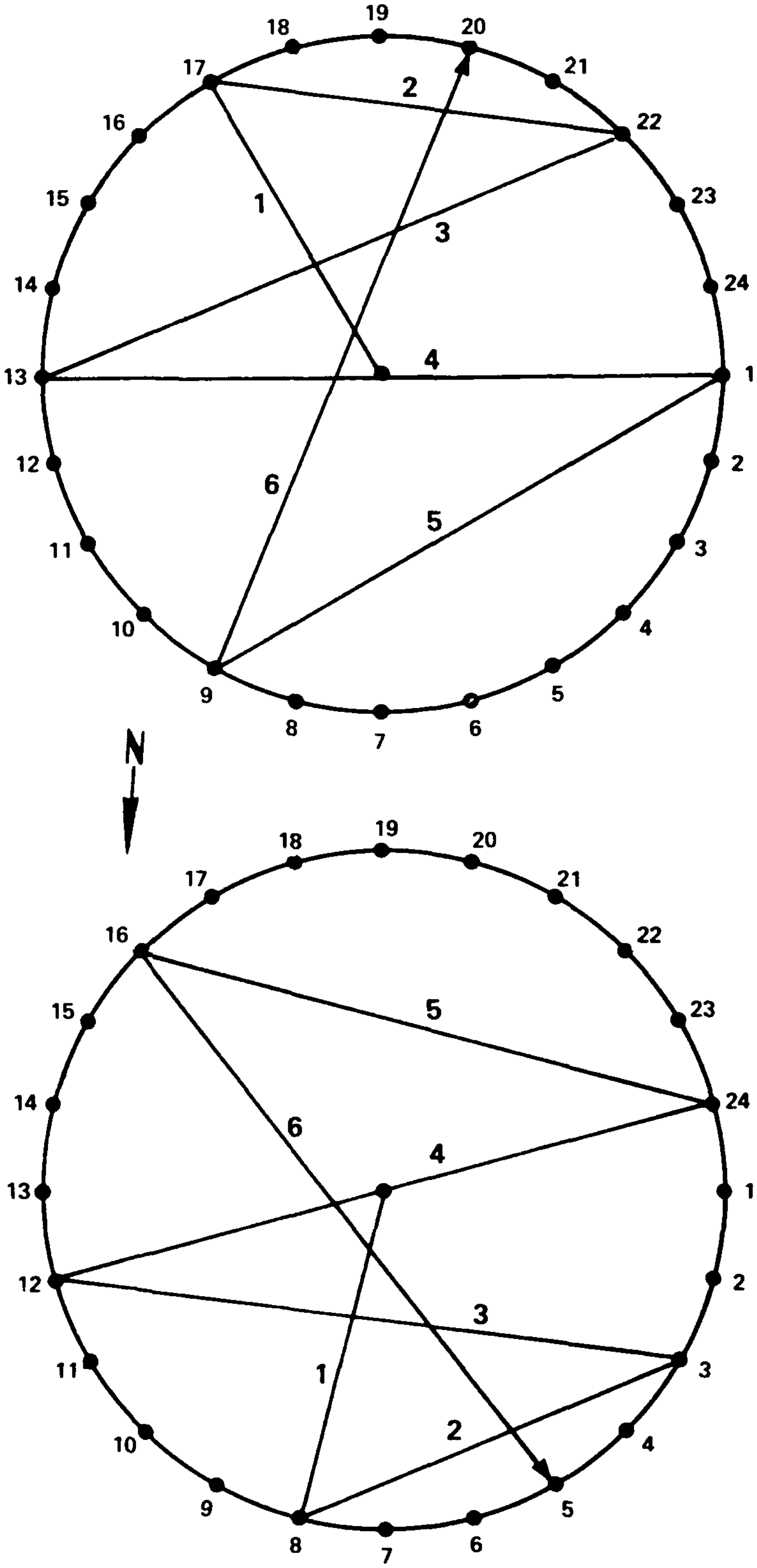


Figure 5. Mirror Image Red and Black Problems (starting in different directions).

COMPASS COURSE
PROBLEM AND SCORE CARD

Problem Number	Azimuth	Stake Number	Number of Meters
1	205		
2	3		
3	138		
4	265		
5	55		
6	198		

Subject No.

Name

Date

Elapsed Time Min Sec
(Nearest Second)

COMPASS COURSE
PROBLEM AND SCORE CARD

Problem Number	Azimuth	Stake Number	Number of Meters
1	310		
2	153		
3	18		
4	250		
5	100		
6	318		

Subject No

Name

Date

Elapsed Time Min Sec
(Nearest Second)

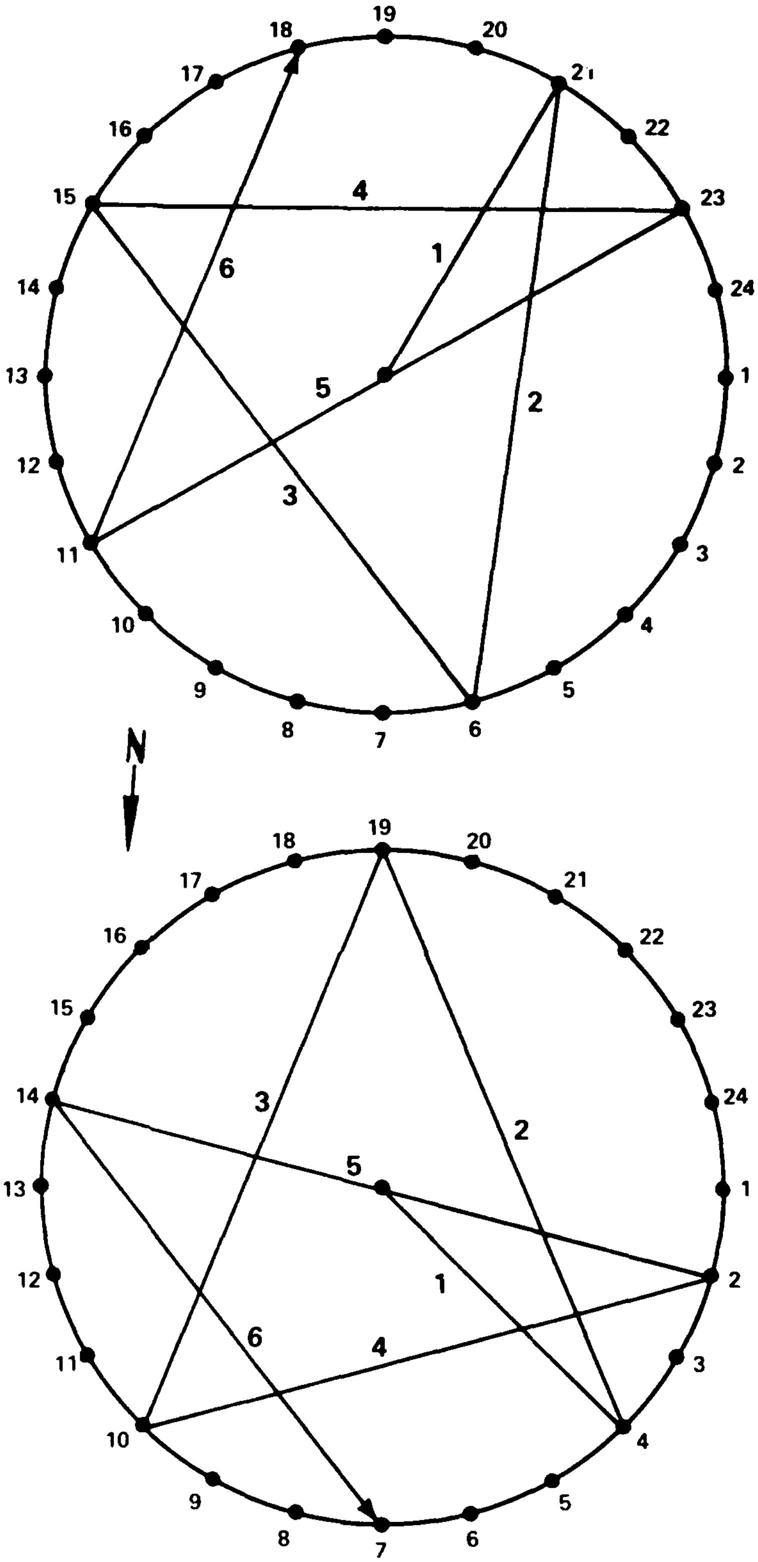


Figure 6. Mirror Image Blue and Green Problems (starting in different directions).

COMPASS COURSE PROBLEM AND SCORE CARD			
Problem Number	Azimuth	Stake Number	Number of Meters
1	145	18 / 17	28 / 24.38
2	273	22 / 21	36 / 24.38
3	63	15 / 13	38 / 38.69
4	265	2 / 23	45 / 48.35
5	55	8 / ✓	28 / 34.49
6	198	21 / ✓	26 / 48.35
Subject No.			
Name			
Date			
Elapsed Time (Nearest Second)	Min	Sec	

— Problem Path
--- Actual Path

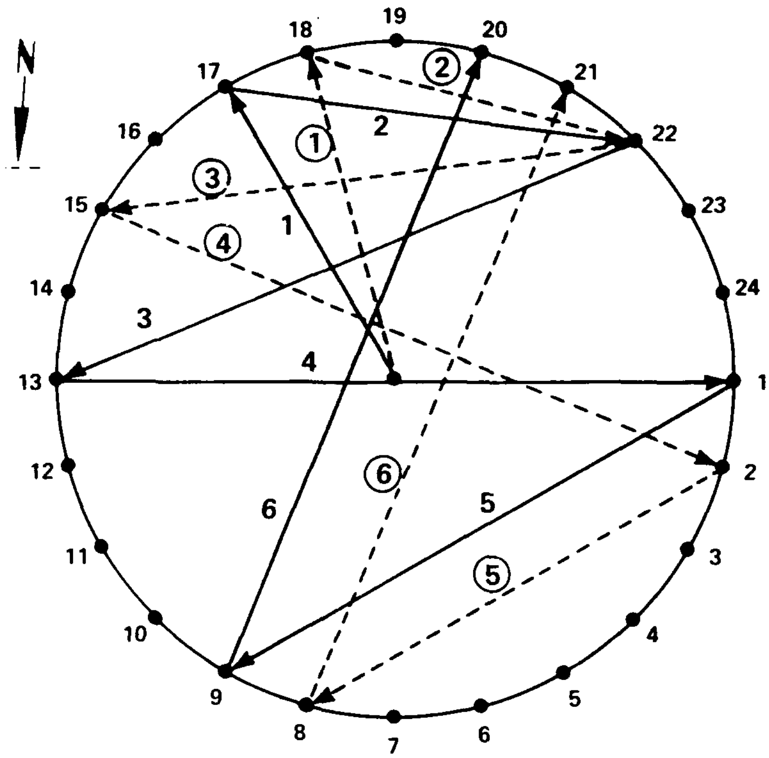
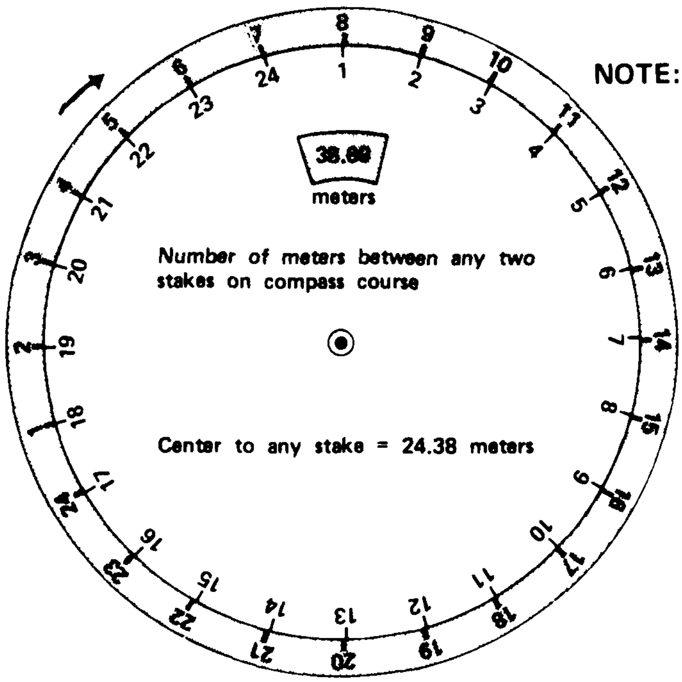


Figure 7. Scoring Schemes of Typical Problems.



NOTE: Discs are turned to match stake numbers. True meters between stakes were straight-line distances determined mathmatically.

Figure 8. Circular Conversion Chart for Scoring True Distances Between Stakes.

Step 6 The same procedure was followed for the remaining four segments. The solutions are summarized below:

Segment Number	Azimuth (degrees)	Started From Stake No.	Should Have Arrived At	Arrived At Stake No.	Segment	Errors (R/L)	Distance (m) Est	Distance (m) True	Error (m)
1	145.0	Center	17	18	No	1R	28	24.38	+ 3.62
2	272.5	18	21	22	No	1R	36	24.38	+11.62
3	62.5	22	13	15	No	2R	38	38.69	- 0.69
4	265.0	15	23	2	No	3R	45	48.35	- 3.35
5	55.0	2	8	8	Yes	0	28	34.49	- 3.51
6	195.5	8	21	21	Yes	0	26	48.35	+22.35

Nine scores were derived for each subject who performed a six-segment problem. The score names and numerical values from the above example are shown below.

Score Name	Example Value
Number Correct Segments	2
Number Stakes Off Left	0
Number Stakes Off Right	7
Number Stakes Off Total	7
Distance Over Estimated	37.59 meters
Distance Under Estimated	7.55 meters
Distance Absolute Error	45.14 meters
Six-Segment Time	12.13 minutes
Travel Rate (Sum of True Distance/Time)	18.00 meters/minutes

B. RELIABILITY OF TEST METHODS

Rationale. Reliability refers to the repeatability of measurement. Any measurement of an individual's ability or performance is influenced by a certain amount of chance that may change his score one way or the other. That chance variation throws some doubt as to exactly where on the scale of measurement his true ability lies. Reliable tests are relatively free from chance variations in scores, and they pinpoint true ability levels more precisely. They are more useful in identifying small differences that may exist between individuals or groups. Therefore, it is a goal in test development to produce a reliable measurement system.

Pertinent questions concerning the reliability of the land navigation test system concern the difference between land navigation scores obtained before and after 2 hours of MPPC activity. How much of that difference is chance variation? To answer this question, a control group of 20 soldiers took the land navigation test twice. Two hours of rest between tests were substituted for the 2 hours of activity that would normally be experienced when testing an Army materiel item for tropic portability. Thus, with the normal activity eliminated, a reliable test system would be expected to produce comparable before and after scores. The correlation of this set of control group before and after scores provides a test-retest reliability coefficient (r_{xx}). That coefficient expresses the proportion of score variability that is free from random variation (i.e., not due to chance or more stable overtime).

The reliability coefficient (r_{xx}) can be used along with the standard deviation of test scores (s_x), to calculate the standard error of measurement (s_e) as follows: $s_e = s_x\sqrt{1-r_{xx}}$. The standard error of measurement describes the span of scores within which an individual's true score may be expected to lie. Ninety-five percent of the time, the individual's score is expected to fall within 2 s_e on either side of his obtained score.

Procedure. On three days in February 1974, 20 combat infantry soldiers from the 193d Infantry Brigade (Canal Zone) were instructed and tested on the land navigation course. Soldiers were tested in groups of two. Three groups of two were tested on each of two days; four groups of two were tested on the third day. The schedule of testing for a given day is shown in table 1. The two soldiers in each group were tested simultaneously, but independently.

Table 1. Daily Land Navigation Test Schedule

Time	Instructions and Practice	Land Navigation Test Before	Two Hours of Rest	Land Navigation Test After
0830	1st group			
0900	2nd group	1		
0930	3rd group	2	1	
1000	(4)th group	3	1,2	
1030		(4)	1,2,3	
1100			1,2,3,(4)	
1130			2,3,(4)	1
1200			3,(4)	2
1230			(4)	3
1300				(4)

NOTE: (4) = Schedule for fourth group on the third day.

Soldiers who were tested with the red problem on the "Land Navigation Test Before" were retested with the mirror image black problem on the "Land Navigation Test After." Similarly, black-before was followed by red-after. Mirror image blue and green problems were used in the same manner. The procedure, then, scheduled each color problem to be used five times as a before-test and five times as an after-test. Use of the color problems was also distributed evenly across the time of day. Order of testing and possible diurnal effects were thus counterbalanced by the test design.

For each of the 20 soldiers, data for 20 variables were recorded. Two variables were personal data of rank and general technical ability (GT). The GT, as recorded in the soldiers' personnel records, is based on verbal and arithmetic tests administered at the time of entry into the Army. GT is recorded in units of the Army Standard Score Scale that has a mean of 100 and a standard deviation of 20 for the Army population. The other 18 variables were the two sets of land navigation scores described in the previous section of this report--one set obtained before rest, the other set obtained after rest.

III. RESULTS

A. RELIABILITY

Data for the 20 soldiers were complete with the exception of one GT score. The variables, their means, standard deviations, and intercorrelation coefficients are detailed in table 2. The soldiers, acclimatized troops (MOS 11B) from the 193d Infantry Brigade (Canal Zone), were in excellent physical condition, were in the average mental ability range, and were eager learners and enthusiastic performers.

The test-retest reliability of the land navigation course may be gauged by the correlation of before and after scores for the four basic measures obtained on the course (abstracted from table 2):

Variable	Measure	Correlation Coefficient for Before Versus After Scores	
3, 4	Correct Segments	.34	Not Sig.
9, 10	Total Stakes Off	.33	Not Sig.
15, 16	Distance, Absolute Error	.83	Sig. @ 0.01
19, 20	Travel Rate	.69	Sig. @ 0.01

Scatter diagrams associated with these four reliabilities are shown in figure 9. The reliability coefficients and scatter diagrams show that the distance estimate and the travel rate scores were more stable over time than were the scores for correct segments and number of stakes off. One reason was that the "distance" and "time" units of measurement, meters and minutes, provided a wider range of possible scores, making them sensitive to small differences in ability. The zero-to-six range for number of correct segments, and the zero-to-seven range for number of stakes off could be increased by increasing the number of segments in the problem; their reliabilities would also increase. However, for purposes of measuring performance-decrement in association with a 2-hour man-pack portability test in the jungle, it was desirable to keep the before and after tests to a minimum of time and stress on the soldier, so that the primary test, portability, would not be affected adversely.

As explained previously, the standard error of measurement (s_e) denotes the limits within which a soldier's true ability is expected to lie; 2 s_e describes the 95-percent confidence interval (CI) for an individual score. Figure 9 shows the value of s_e for the four types of land navigation measurement. The following tabulation shows the 95-percent CI about an individual score:

Score	95% CI = 2 s_e
Number of Correct Segments	1.8 segments
Number of Stakes Off	2.8 stakes
Distance Estimate Error	22.2 meters
Travel Rate	5.0 meters/minute

Table 2. Means, Standard Deviations, and Intercorrelation Coefficients of 20 Variables

No.	Variable: Name		Unit	Mean	S.D.	Intercorrelation Coefficients a/: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Rank		E	3.7	0.1																			
2	GT Score b/		std.	85.8	12.8	13																		
3	Correct Segments	Bc/	No.	2.9	1.4	-08	01																	
4		A		3.3	0.9	26	08	34																
5	Stakes Off, Right	B	No.	3.3	2.0	21	-27	-81d/	-22															
6		A		3.1	1.8	-05	-08	-32	-74d/	28														
7	Stakes Off, Left	B	No.	0.6	1.0	-13	24	21	-12	-57d/	08													
8		A		0.3	0.7	-25	00	05	-14	-18	-38e/	-05												
9	Stakes Off, Total	B	No.	3.9	1.7	18	-20	-85d/	-34	87d/	39e/	-10	-25											
10		A		3.4	1.7	-16	-08	-33	-85d/	23	93	07	-02	33										
11	Distance Over Estimate	B	meters	19.8	27.1	-04	-02	-21	-33	30	51e/	-05	-10	33	51e/									
12		A		17.6	21.0	-14	10	16	-24	-10	32	-01	06	-13	37	81d/								
13	Distance Under Estimate	B	meters	18.9	24.5	29	24	-05	-16	-05	14	35	-26	14	04	-38e/	-45e/							
14		A		24.9	29.0	19	11	-24	-18	06	17	36	-22	29	10	-38e/	-55d/		93d/					
15	Distance Absolute Error	B	meters	38.7	28.8	21	18	-24	-44e/	23	60d/	25	-32	43e/	52d/	62d/	38e/	49e/	43e/					
16		A		42.4	24.8	09	21	-15	-41e/	-02	47e/	41e/	-20	22	43e/	24	20	70d/	71d/	83d/				
17	Six Segment Time	B	minutes	20.6	5.8	-05	-02	-47e/	-49e/	48e/	42e/	-08	15	54d/	51e/	38e/	29	-10	-11	27	12			
18		A		16.7	4.9	00	11	-41e/	-34	45e/	41e/	-12	-15	47e/	39e/	25	17	16	04	37	20	75d/		
19	Travel Rate	B	m/min	11.7	3.7	07	34	43e/	36	-51e/	-38e/	12	-11	-55d/	-45e/	-18	-04	09	00	-09	-04	-86d/	-65d/	
20		A		15.3	5.1	05	00	34	35	-43e/	-39e/	18	06	-42e/	-40e/	-12	-04	-13	-05	-23	-09	-69d/	-93d/	69d/

a/ Decimal points omitted.
b/ For GT, N = 19; for all other variables, N = 20.
c/ B = Before 2-hour rest; A = After 2-hour rest.
d/ Significantly different from zero at .01 significance level.
e/ Significantly different from zero at .05 significance level.

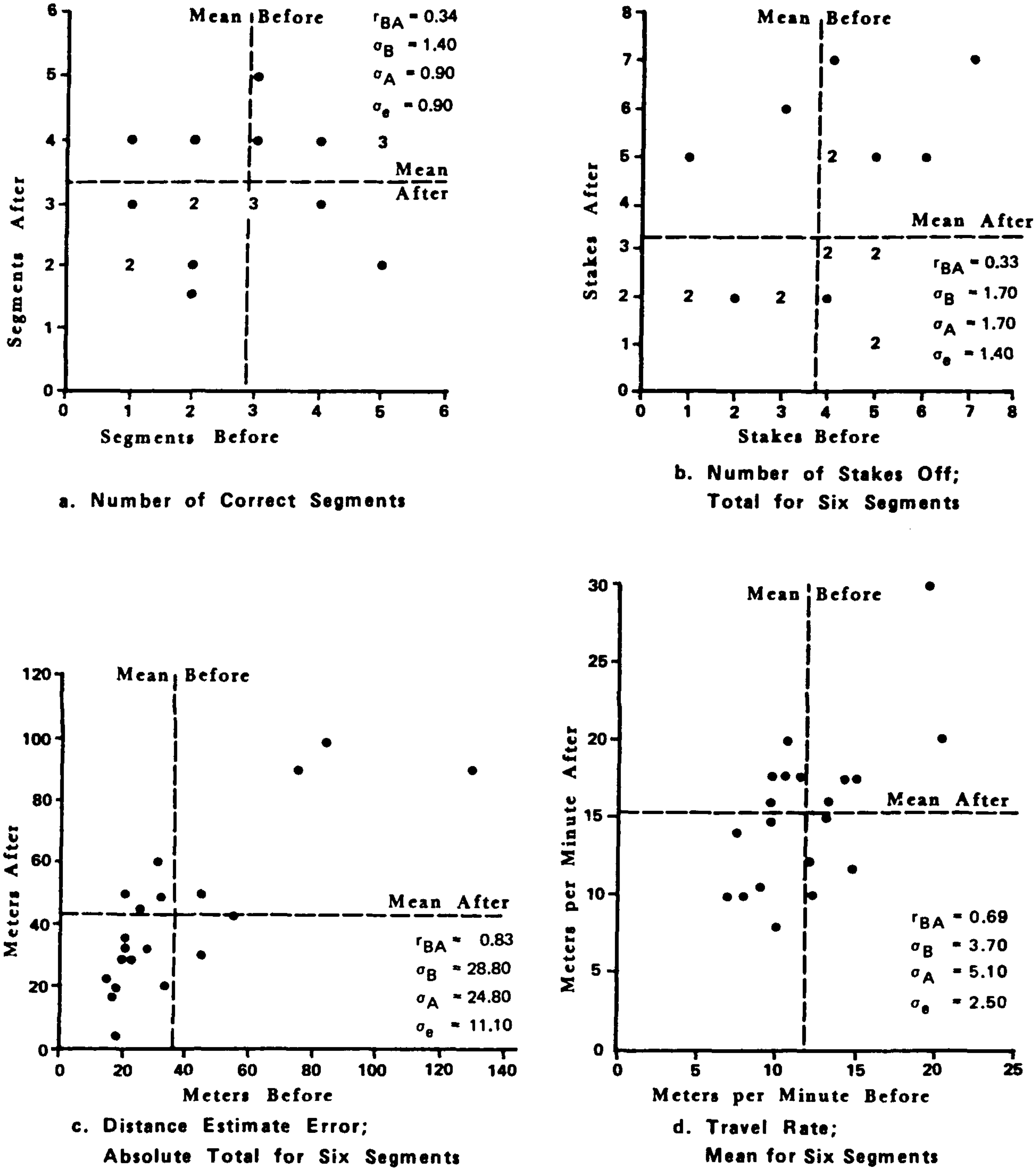


Figure 9. Scatterplots of Before and After Scores for 20-Soldier Control Group.

Based on this reliability investigation, an individual whose before and after land navigation scores are separated by more than the above 95-percent CIs may be considered as significantly affected in land navigation ability by traversing the MPPC. Future studies will provide similar data for persons who traverse the MPPC while carrying various loads.

B. EQUIVALENCE AMONG FORMS

Some tests have more than one form. Alternate forms are helpful when an individual must be retested within a short period of time. Slightly different questions and solutions on an alternate form help to reduce positive recall and inflated scores on the second test. A possible disadvantage of multiple forms is that the forms may produce different scores because they are not equal, for instance, in difficulty.

In order to answer questions concerning equivalence of forms, test data from the 20 soldiers of the control group were analyzed separately by problem color--red, black, blue and green as diagramed in figures 5 and 6. Only scores from initial tests (before rest period) were used. Table 3 gives the means and standard deviations for the four types of measures for each of the four different problems.

Table 3. Comparison of Test Scores Across Alternative Problems

	PROBLEM			
TYPE OF SCORE	RED	BLACK	BLUE	GREEN
Number of Segments				
Mean	3.6	3.6	2.8	1.4
Standard Deviation	1.3	0.9	1.6	0.6
Number of Stakes Off				
Mean	2.8	2.8	4.2	5.6
Standard Deviation	1.3	1.8	0.8	0.9
Distance Estimate Error (meters)				
Mean	23	33	41	58
Standard Deviation	4	13	24	49
Travel Rate (meters/minute)				
Mean	12	14	11	9
Standard Deviation	2	6	3	2

Table 4 is a summary of an analysis of variance performed on the same data. Soldiers were nested randomly within problems (five to a problem) with repeated measurement across the four types of measures. Problems and types of measures were fixed effects.

Table 4. Summary Analysis of Variance for Problem Difficulty

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARE	F
Problems	3	71,483	23,828	0.43
1 Red vs Black	(1)	67,240	67,240	1.21
2 Blue vs Green	(1)	705	705	0.01
3 (R + BK) vs (BU + G)	(1)	3,538	3,538	0.06
Measures	3	18,257,343	6,085,781	123.91
1 TR vs DE	(1)	6,188,969	6,188,969	126.01
2 (TR + DE)/2 vs SO	(1)	8,035,222	8,035,222	163.60
3 (TR + DE + SO)/3 vs SC	(1)	4,033,152	4,033,152	82.12
Problems X Measures	9	880,438	97,826	1.99
P1 X M1	(1)	22,178	22,178	0.45
P1 X M2	(1)	44,827	44,827	0.91
P1 X M3	(1)	22,413	22,413	0.46
P2 X M1	(1)	187,792	187,792	3.82
P2 X M2	(1)	552	552	0.01
P2 X M3	(1)	163	163	0.00
P3 X M1	(1)	598,781	598,781	12.19
P3 X M2	(1)	2,803	2,803	0.06
P3 X M3	(1)	929	929	0.02
Soldiers (P)	16	885,837	55,364	
Measures X Soldiers (P)	48	2,357,557	49,116	
TOTAL	79			

NOTES: TR = Travel Rate
DE = Distance Estimate
SO = Stakes Off
SC = Segments Correct

In the "problems" source of variance (table 4), no differences among problem difficulty were indicated at the 0.05 level of statistical significance. Separate comparisons of the red versus black and the blue versus green problems showed that there were no differences between a problem and its mirror image counterpart. The third problem comparison was between the two basically different problem patterns--red and black versus blue and green.

The red-black pattern was not statistically different from the blue-green pattern using all four measures combined as the basis of comparison (P3 contrast F = 0.06). However, there was a significant difference in problem patterns with respect to their score levels on travel rate versus distance estimate (P3 X M1 interaction F=12.19, P < 0.01). By referring to table 3, it can be seen that, where the errors in estimating distance were low (red and black problems), the travel rates were faster; where the errors in estimating distance were higher (blue and green problems), the travel rates were slower. Walking faster was associated with making fewer distance estimate errors; or walking slower is associated with making more distance estimate errors. It may be that walking faster generates fewer such errors. Another explanation for this effect may be in the factors that contribute to travel rate. Travel rate is calculated by dividing true distance traveled by overall time. The overall time includes not only the time spent walking, but also the time spent standing still while recording stake numbers and estimating distance traveled for each of the six segments of the problem. Because distance estimation is largely a mental arithmetic exercise, a reason for the significant interaction effect may be that soldiers who are less capable of handling the mental task take more time and make more errors in estimating distance (assuming equal rates of movement when actually walking). Mental ability, as measured by GT (verbal and arithmetic reasoning) was not significantly different for persons who were tested with the red-black versus blue-green problems (84.3 versus 87.3, respectively, t = 0.51, p > 0.05), thereby lessening the chance that difference in intelligence may be the cause of the significant interaction. The stability of that significance and possible reasons for the interaction effect (if significantly stable) may be investigated as future data become available for cross validation studies.

C. SUMMARY AND CONCLUSIONS

A short land navigation test course was established in the Canal Zone to serve as a performance-decrement test for soldiers who carry materiel items on portability tests at USATTC. Instructions and practice in land navigation were given to each of 20 combat MOS soldiers. The subjects reviewed the parts of the compass, their functions, and techniques for use of the instrument. Each subject practiced pacing a distance of 10 meters for distance estimation. Each soldier was given three practice problems and was critiqued on his performance. After practice, each subject performed a six-segment problem. Direction accuracy, estimation of distance, and time to perform were the factors scored. Nine specific scores were derived for each subject who performed the problems: number of correct segments; distance off to the left, right, and total; over- and under-estimates of distance walked; and time.

Reliability coefficients and standard errors of measurement showed that scores based on estimating distance walked and on travel rate were more stable over time than were the scores for the number of correct segments and the number of stakes off.

A separate analysis of internal consistency of the test was performed to determine equivalence of the four different six-segment problems--coded red, black, blue, and green. Travel rate, distance estimation, stakes off, and segments correct were the four variables compared. The red-black (mirror images) pattern was not significantly different from the blue-green (mirror images) pattern where all four measures were combined. There was a significant interaction of problem patterns with respect to their score levels on travel rate versus distance estimation.

Overall, the land navigation test proved to be a reliable performance-decrement measure. It is recommended for use in conjunction with the established man-pack portability test to aid in determining the suitability of Army materiel during jungle patrols.

APPENDIXES

APPENDIX A. TAPED INSTRUCTIONS FOR LAND NAVIGATION COURSE

Tape I

Today's activity consists of navigating a compass course. To do this, you must understand two things: (1) Be able to use a compass properly, and (2) be able to pace off distance. To make sure that you can do both, we will have a review and practice. This is a lensatic compass. There are certain precautions regarding the care and use of the compass. Handle the compass with care; the dial is set at a delicate balance which a shock could damage. Closing the compass locks the dial and protects the glass lens and the sighting wire. Watches and steel rim glasses will have an effect on the operation of the compass. Remove your watch now if you have one. Remove steel rim glasses that do not have a prescription lens.

Now pay careful attention to the way we tell you to use the compass. Everyone must use the compass in the same way in order for the test results to make any sense. Also the way we will show you will give you the most accurate results. Pay careful attention while we point out the important parts of the compass: (1) the sighting wire; (2) the sighting slot; (3) the lens; (4) the index line; and (5) the thumb loop. There are a few things to know about the compass. The sighting slot and lens are movable. Adjust the lens so that when you hold the compass up to your eye you can read the numbers on the face of the dial and still see through the slot and past the sighting wire. Don't push the magnifying lens down too far or it will lock the compass needle in place. The dial moves and is always seeking magnetic North. Note that there are two rings of numbers on the compass. Use the inner ring of numbers as this is in degrees. The outer ring of numbers is in mils and they are of no concern here today. There is a number at each 20-degree marker, starting at zero degrees, or North. Between each marker there are other marks each at 5 degrees apart. Between the 5-degree markers, you can estimate 1, 2, 3 or 4 degrees.

Watch, while we demonstrate the proper way to hold a compass. Hold the compass level with the thumb through the thumb loop and extending under the compass like this. (Demonstration) The left hand should support the right hand and the compass. Place the lens and sighting slot right up to your eye. Be sure the compass is level. Glance down through the lens and rotate your body until you see the azimuth you are hunting for directly under the index line. Then you should be pointing in the right direction. Everyone do this now. (Pause) Place your thumb through the thumb loop and extend your thumb underneath the compass. The left hand should support the right hand and the compass. Place the lens and the sighting slot right up to your eye. Be sure the compass is level. Each person shoot an azimuth of 40 degrees. Glance down through the lens and rotate your body until you see the 40-degree mark underneath the index line. (Pause) You are now pointing at 40 degrees.

In a few minutes we will have a practice session. At that time you will use the compass like we have shown you. You will be given an azimuth to follow. Hold the compass like we have shown you and glance down through the lens and rotate your body until you see the azimuth underneath the index line. You will then be pointing in the correct direction. Hold the compass and your body steady with the index line over the correct azimuth and line up the sighting slot and sighting wire with an object. Glance down again to make sure you are still on the correct azimuth. Lower the compass and walk directly toward the object you have selected, counting the number of steps as you go. When you get to the object use the compass again to pick out another object along the same azimuth, then walk toward the new object continuing your step count. Follow this procedure until you arrive at a white stake with a black number on it. When you arrive at a stake, write its number on your score card and also the number of meters you have walked. Be sure to add up the distances from object to object, as this is the distance that goes on your score card. Do you have any questions?

Now let's have a little practice. Step over here. Over here is a distance of ten (10) meters marked between the two (2) markers. One (1) marker here; and up there, the other marker. Each man must pace the distance to see how many steps it takes him to walk the ten-(10) meter distance. In this way you will be able to gauge the distance you walk on the compass course. Walk it two (2) times; once in each direction to get an average for your step size. Walk it at a natural pace. Remember how many steps it takes to walk ten (10) meters, so you will be able to determine the distance you walk from point to point on the compass course. Do this now. Walk the ten-(10) meter course two (2) times. Count your steps each time and average the two numbers. Remember your average number of steps in the ten (10) meters. If you are not sure, walk it again.

Now we will do a practice compass course exercise. Here is a card with two (2) practice problems on it. Do problem number one, starting here. Walk on the azimuth until you find a white 2- by 4-inch stake with a black number on it. Remember, a white 2- by 4-inch stake. Record the number of meters you walked. Remember, the number of METERS, not the number of steps. Start the next problem by holding the compass directly over the stake you found. Now do either of you not know how to use the compass? Or estimate the distance? Or what we are going to do today? If you do not understand, now is the time to ask questions. Okay, start problem number one now, first one man and then the other. When you have completed the two problems, return here to this station. At that time we will review your work to see if you have done the procedure correctly. Are there any questions? Okay, start now.

Tape II

Each man take a card. Print your name, Social Security Number and the date if it is not already there at the bottom of the card. Place your assigned number where it says subject number.

Okay, look at the card. Under the problem numbers you can see the numbers one through six; follow them in sequence. Sight the azimuth indicated, then walk counting your steps until you reach a white stake with a black number on it. This will be a small stake about 1 foot out of the ground. Record that number in the block next to the azimuth. To the right of that, record the number of meters you walked. Remember, you have to change the number of steps into meters. You do this according to the number of steps it took you to walk ten (10) meters. Write the number of steps it took you to walk ten (10) meters in the indicated space on your card. Start segment number one here at this stake. For the next segment hold the compass directly over the stake you found in the first segment. Repeat the same procedure until you have completed all six (6) segments. If you think you are going off course, reshoot the azimuth from where you are. Do not go back to the stake where you started. If you get one segment wrong, it will not affect your score on any of the other segments. Are there any questions? Okay, remember, complete the segments as quickly as you can without getting off course. If you reach a white tape, stop, because that is the boundry of the course. Now start segment number one.

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